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AUTHOR Wang, Margaret C.; And Others
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ABSTRACT

The objective of the Adaptive Learning Environments Model (ALEM) is to establish and maintain school environments that ensure optimal learning success opportunities for most students through adaptive instruction. Modification of the environment to accommodate student differences has been an important design consideration in the development of the ALEM. The program's design incorporates the use of interventions when necessary to modify a student's capability to function. An overview of the program design and supporting research associated with development, implementation, and evaluation of the ALEM are presented. Results of studies are organized into major categories. These include the degree of implementation of the program in a variety of school settings and the program's impact on classroom processes, teacher time use, and student achievement in mathematics and reading. The implications of the findings from the perspectives of instructional design, program evaluation, and research methodology are discussed. (Author/DWH)

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The Adaptive Learning Environments Model: Design, Implementation, and Effects

Margaret C. Wang, Patricia Gennari, and Hersholt C. Waxman

Learning Research and Development Center
University of Pittsburgh

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Abstract

This paper provides an overview of the program design and supporting research associated with development, implementation, and evaluation of the Adaptive Learning Environments Model. Results from analysis of data on program implementation and impact, in terms of classroom processes, teacher time use, and student achievement, are reported from four studies conducted at a total of 11 different school sites over a three-year period. Implications of the findings from the perspectives of instructional design, program evaluation, and research methodology are also discussed.

The Adaptive Learning Environments Model: Design, Implementation, and Effects

The overall goal of the Adaptive Learning Environments Model (ALEM) is to establish and maintain school environments that ensure optimal opportunities for learning success for most, if not all, students through the provision of adaptive instruction. The program's design is based on the premises that students learn in different ways and at different rates and that one alternative for maximizing learning is to provide instruction which adapts to those differences. Furthermore, the accommodation of student differences requires a variety of instructional methods and learning experiences that are matched to the learning characteristics and needs of individual students, as well as explicit interventions that increase each student's capabililty to profit from available instructional and learning alternatives. Thus, modification of the environment to accommodate student differences (e.g., use of alternative instructional strategies, provision of different amounts of instruction, allowance for individual differences in rates of learning, provision of a variety of learning options) has been an important design consideration in the development of the ALEM. In addition to necessary adjustments in the learning environment, however, the program's design incorporates the use of interventions, when needed, to modify each student's capability to function under, and profit from, such school learning environments (Wang, 1980a).

DESIGN OF THE PROGRAM

Essentially, the ALEM's curriculum combines prescriptive, or "direct," instruction that has been shown to be effective in ensuring mastery of basic academic skills (Bloom, 1976; Glaser, 1977; Rosenshine, 1979) with aspects of informal, or open, education that are considered to be conducive to generating attitudes and processes of inquiry, self-management and responsibility for learning, and social cooperation (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Marshall, 1981; Peterson, 1979; Wang, 1983a; Wang & Stiles, 1976). Among the expected program outcomes for students are increased competence and confidence in their own abilities to successfully acquire skills in academic learning and in management of their behaviors and the classroom environment. At the same time, a hign degree of program implementation is expected to result in increased amounts of time spent by teachers providing instruction rather than managing students.

Figure 1 shows the conceptual model of program design and evaluation research that has provided the basis for the program of research leading to development and validation of the ALEM. As shown in Figure 1, the model consists of three major components. The first is the program design component (shown by the rectangular boxes on the left-hand side Figure 1). The second component is related to program implementation in school settings (represented by the circle); and the third component focuses on evaluation of related process and product outcomes.

Insert Figure 1 about here

Program design begins with the identification of instructional goals and student characteristics. This information constitutes basic input into the design of those program dimensions that are critical for the ongoing provision of adaptive instruction in classroom settings, as well as those dimensions related to classroom-level support for program implementation. The arrows in Figure 1 suggest that outcomes are evaluated in relation to (a) the actual presence or absence of critical program dimensions; (b) the extent to which implementation of the dimensions leads to specific classroom processes that are hypothesized to be characteristic of adaptive instruction; and (c) the extent to which the classroom processes lead to students' social and academic competence.

Two categories of critical program dimensions have been identified as classroom-level requirements for effective implementation of adaptive instruction (see the two large rectangular boxes on the left-hand side of Figure 1). These dimensions are related to the process of providing adaptive instruction, and the classroom management and resource supports required for effective implementation of adaptive instruction. The dimensions associated with effective provision of adaptive instruction are Creating and Maintaining Instructional Materials, Developing Student Self-Responsibility, Diagnostic Testing, Instructing, Interactive Teaching, Monitoring and Diagnosing, Motivating, Prescribing, and Record Keeping. Dimensions identified as critical for supporting classroom implementation of adaptive instruction are Arranging Space and Facilities, Establishing and Communicating Rules and Procedures, and

Managing Aides. It is important to note here that, insofar as they represent program design features and classroom practices that have been found to be effective by many researchers and practitioners (Brophy, 1979; National School Public Relations Association, 1981; Walberg, 1983), the individual program dimensions are not unique to the ALEM. The uniqueness lies in the complementary functions served by the planned clustering and systematic integration of the dimensions into a comprehensive program. In fact, the contention is that the presence of any single dimension is unlikely to lead to effective adaptive instruction. (See Wang, Catalano, and Gromoll, 1983, for a discussion of the design and operation of the program dimensions.)

Development of the ALEM has been associated with two primary lines of supporting research. As outlined in the bottom box of Figure 1, this research has consisted of empirical studies related to program design and program evaluation studies of implementation and outcomes. The first line of research--empirical studies related to program design--can be characterized as instructional experimentations associated with the development of program components. The focus of this research has been the operationalization and integration of what is known from psychological theories of learning, and from research on instructional methods and effective schooling practices, in the design of educational environments that successfully accommodate students' diverse needs. Examples of this work include development and validation of curricular hierarchies in the various basic skills areas (Resnick, Wang, & Kaplan, 1973; Wang, Resnick, & Boozer, 1971); development of diagnostic tests and student progress monitoring procedures (Glaser, 1967; Lindvall &

Cox, 1967; Wang & Fitzhugh, 1978); development of a student self-responsibility training program (Smith, 1976; Stone & Vaughn, 1976; Wang, 1983); and development of a data-based, staff development program (Wang, 1981; Wang & Gennari, 1983).

The second line of supporting research has addressed questions related to program implementation and evaluation. Specific research questions have dealt with the practicalities of implementing adaptive instruction in school settings and with program efficacy. Studies have focused on investigating what it takes to implement and maintain an adaptive instruction program, whether or not it is feasible to implement such a program widely in different school settings, and the manner and extent to which various components can be put together in complementary ways to form a cohesive and comprehensive program for school implementation. In addition, research in this area has been designed to characterize the actual operation of the ALEM for the purpose of answering basic program development and refinement questions such as, "How can we do it better?"; and, "For whom, and under what conditions, is the program effective?"

Essentially, the studies of program implementation and efficacy have been aimed at investigating (a) the extent to which implementation of various program components leads to the presence of those specific classroom processes that are hypothesized to support the provision of adaptive instruction; and (b) the extent to which the presence of those classroom processes leads to student achievement. Examples of such studies include analysis of program impact on teachers' and students' use of time (Wang, in press a, 1983b; Wang & Walberg, 1983) and

evaluation of learning processes and outcomes in a variety of school sites (Wang, in press b; Wang & Birch, 1984; Wang, Leinhardt, & Boston, 1980; Wang, Peverly, & Randolph, in press; Wang, Resnick & Scheutz, 1974; Wang & Walberg, 1983).

PROGRAM IMPLEMENTATION AND RELATED EFFECTS: A SUMMARY OF MAJOR FINDINGS

Findings from four recent studies of the ALEM's implementation in a variety of school settings and its related effects are summarized in this section. These studies were designed to address the following three sets of questions.

1. Can a high degree of implementation of the ALEM's critical dimensions be attained in classroom settings across a number of school sites with different needs and contextual characteristics? In other words, is there evidence of the program's implementability or feasibility in varying school settings?

2. When the ALEM's critical dimensions are in place, do the hypothesized patterns of classroom processes occur; and, to what extent do the classroom process patterns differ from, or concur with, the hypothesized trends?

3. Do the ALEM (as characterized by degree of implementation data) and its resulting classroom process patterns lead to expected student outcomes?

Briefly, Study I was designed to investigate program implementation and effects in 117 classrooms at six school sites where the ALEM was implemented in conjunction with the local school districts' participation in the National Follow Through Program during the 1980-81 school year. (Follow Through is a nationwide compensatory education program sponsored by the U.S. Department of Education.) Study II was carried out during 1980-81 in 21 classrooms at school sites where the focus was on assessing the efficacy of the ALEM as the core educational program in regular classrooms in which mildly handicapped and gifted students were mainstreamed on a full-time basis. Study III was a replication of Study I; it was carried out at five collaborating school sites that participated in the National Follow Through Program during the 1981-82 school year. Study IV was a replication of Study II; it was conducted during the 1982-83 school year in 28 mainstreaming classrooms in five schools within a large urban school system.

Discussion of the results from the studies is organized under two major headings: the degree of implementation of the ALEM in a variety of school settings; and program impact on classroom processes, teacher time use, and student achievement in math and reading. It should be noted here that, while the four studies shared the overall goal of examining the school implementation and effects of the ALEM, different research questions were addressed. Thus, the specific variables included in the studies differed somewhat from one study to another, as did the measures. Discussion of results related to specific research questions, therefore, may not include data from all four studies. In each case, however, the reported data represent all that are available from all four studies.

Degree of Implementation

Data on degree of implementation were used to address four specific questions related to the implementability of the ALEM. These questions are (a) "To what extent was an overall high degree of implementation attained across a variety of school sites?"; (b) "To what extent did the degree of implementation improve over time?"; (c) "Were there significant differences in the patterns of implementation among classrooms with different overall degree of implementation scores?"; and, (d) "Were there differences in the degree of implementation of adaptive instruction in classrooms where the ALEM was implemented and classrooms where the program was not implemented?"

Overall Degree of Implementation

The Implementation Assessment Battery for Adaptive Instruction (Wang, 1980b) was used to obtain data on the degree of program implementation. The Battery, which is designed to assess the presence and absence of the critical dimensions of the ALEM, is based on a series of performance indicators that have been identified through systematic analysis of the program's structural and action domains. The structural domain consists of the resources, such as materials, space, facilities, time, and personnel, required to create the conditions under which adaptive instruction can be implemented effectively (i.e., the support systems for program implementation in classroom settings). The action domain consists of the roles and behaviors of instructional staff (i.e.,

the process related to provision of adaptive instruction) and students.

Table 1 provides a summary of the results from the analysis of degree of implementation data from all four studies. To investigate the extent to which a high degree of implementation of the ALEM was able to be established in a variety of school sites (i.e., program implementability), the mean spring degree of implementation scores (as shown in the last column under each study) were examined. The implementability of the ALEM is suggested by the generally high spring degree of implementation scores across all 12 critical dimensions and by the overall spring scores for the four studies. As shown in the last row of the table, the overall average spring scores for all four studies were above 85%--the criterion level for a high degree of implementation.

Insert Table 1 about here

Improvements in Program Implementation

A critical test of the ALEM's implementability is the extent to which the degree of implementation at the participating sites improved over time. To this end, the mean scores for fall, winter, and spring for each study were examined. A consistent pattern of steady improvement in the implementation of the critical dimensions over time was noted in all four studies. Furthermore, as shown in Table 1, the differences in the changes in degree of implementation scores for fall, winter, and spring were statistically significant in all cases.

It is noteworthy that, in most cases, the greatest changes in degree of implementation occurred between the fall and winter data collection periods. In a way, this finding is an additional indicator of the program's implementability. It reflects one of the criteria for successful implementation of any school innovation that requires major programmatic changes--the reality is that teachers and students cannot survive under, or cope with, the disruption that can be caused by initiation of an innovative school program for extended periods of time. Successful implementation of new programs is unlikely unless critical dimensions of the programs are implemented at an acceptable level, and a reasonable implementation routine is established and maintained during the initial three months of their operation.

Patterns of Degree of Implementation

Another question of interest in examining the degree of program implementation is whether or not there is a consistent pattern of differences in the implementation of various program dimensions among classrooms at different overall degree of implementation levels. Scores in individual dimensions for classrooms grouped at high, average, and low degree of implementation levels were examined. A class is rated as being at a high degree of implementation level when a score at or above 85% is obtained in 11 or 12 of the critical dimensions. Average degree of implementation classrooms are those with criterion-level scores in six through 10 of the dimensions. Classrooms at the low degree of implementation level have scores at or above 85% in five or fewer critical dimensions. Data from Spring, 1981 for Studies I and II were

used in the analysis. A summary of the mean degree of implementation scores for each of the 12 critical dimensions among the three groups of classrooms is presented in Table 2.

Insert Table 2 about here

When the patterns of high mean degree of implementation scores for each critical dimension were examined, consistent differences among the three groups of classrooms were noted. Moreover, the differences suggest a hierarchy of teacher expertise in classroom implementation of adaptive instruction. As shown in Table 2, for example, the data suggest that all three groups had mean scores at or above 85% in four of the dimensions: Record Keeping, Prescribing, Diagnostic Testing, and Managing Aides. Given the nature of these dimensions, it can be said that, by the end of the school year, all teachers in the ALEM classes at the Follow Through and mainstreaming sites were able to achieve a high level of implementation of the basic mechanics of providing individualized instruction. The major differences between classes in the average and high degree of implementation groups and those in the low degree of implementation group were in critical dimensions related to classroom instruction and management. These dimensions are Arranging Space and Facilities, Establishing and Communicating Rules and Procedures, Monitoring and Diagnosing, Instructing, and Motivating.

Differences between the high degree of implementation group and the average and low groups, on the other hand, were found in three dimensions: Creating and Maintaining Instructional Materials, Interactive Teaching, and Developing Student Self-Responsibility. A high degree of implementation of these latter dimensions requires skill in simultaneous and spontaneous analyses of students' ongoing learning behaviors and needs, knowledge of the nature of the tasks to be learned, and ability to provide instructional resources and learning experiences for meeting individual student needs.

Thus, there seems to be a clear hierarchy of teacher expertise associated with implementation of the ALEM. All teachers--including those whose overall degree of implementation scores were considered to be at the "low" level--had scores at or above 85% (the criterion score) in dimensions related to the basic mechanics of individualizing instruction. However, teachers with overall low degree of implementation scores generally were below the 85% criterion in dimensions related to management of the classroom environment and instruction, as well as those related to the ongoing adaptations required for the instructional-learning process. It is noteworthy that for the latter skills, the 85% criterion was attained only by teachers with overall high degree of implementation scores.

Comparison of Implementation of Adaptive Instruction in ALEM and Non-ALEM Classrooms

To investigate the extent to which there were significant differences in the progress made by ALEM and non-ALEM teachers in implementation of critical features of adaptive instruction, degree of implementation data for teachers from the two groups of classrooms were examined. Data from Study II (the only study that included a comparison group) were used in this analysis. The results are summarized in Table 3. The mean percentage scores in each of the critical dimensions for classrooms at each grade level, as well as the total mean scores for both groups of classrooms, are reported.

Insert Table 3 about here

Two major findings are suggested by the data reported in Table 3. First, an overall high degree of implementation of the critical program dimensions was attained in the ALEM classrooms by the end of the school year (92%), while a comparatively much lower degree of implementation score was noted for the non-ALEM classrooms (46%)--a difference of 46 percentage points. Second, the differences in the degree of implementation scores for the ALEM and non-ALEM classrooms included dimensions that generally are considered to reflect expertise generic to effective instruction (e.g., Establishing and Communicating Rules and Procedures).

Summary

To summarize, findings related to program implementation across all four studies consistently suggest the overall implementability of the ALEM. That is, they provide evidence of the feasibility of establishing and maintaining a high degree of implementation of the critical program dimensions of the ALEM in a large number of diverse school sites that include students from disadvantaged backgrounds and students labeled as having "special" needs. In addition, the findings show that, in general, the ALEM teachers made significant improvements in degree of implementation over time, and differences in patterns of implementation were noted for teachers with overall high degree of implementation scores and those with comparatively lower scores. Furthermore, when the degrees of adaptive instruction in ALEM and non-ALEM classes were compared, the non-ALEM classes scored considerably lower, even in dimensions widely recognized as reflecting generic expertise associated with effective teaching.

Data on implementation of the ALEM in schools challenge current opinion on the implementability of adaptive instruction, or the potential for wide-scale implementation in school settings. The general consensus in the effective teaching literature (e.g., Bennett, 1976; Brophy, 1979) is that effective implementation of adaptive instruction requires considerable teacher expertise and resources. Many have concluded that even if adequate school organizational and resource supports could be provided, the knowledge base on how to develop the teacher expertise required for effective implementation of adaptive instruction in regular class settings is sorely lacking. Furthermore, findings from successful demonstrations of adaptive instruction often

have been attributed in the literature to unusual teachers and/or students. The underlying assumption is that it is extremely difficult to "reproduce" the special sort of teacher (or teacher expertise) required by such programs. Although some concede that individualized and small-group instruction might work under the guidance of master teachers and with adequate organizational and resource supports, and the results under these circumstances could include positive classroom processes, most are quite skeptical.

Thus, the fact that, on the average, teachers in all four studies achieved or exceeded the criterion for a high degree of program implementation indicates their ability to develop the expertise, and/or use the expertise they already possessed, to effectively implement the critical program features of the ALEM. Findings from the studies suggest the feasibility and possibility that, with systematic training, a large percentage of public school teachers can establish and maintain the kinds of school learning environments normally considered to be a possibility only with specially endowed teachers.

Degree of Implementation and Program Outcomes

A central issue in assessing the efficacy of the ALEM has been the extent to which implementation of the critical dimensions of the program leads to intended outcomes. In other words, the question has been, "Does the program work as predicted?" Thus, the focus of analyses of the program implementation and outcomes data has been on investigating the relationships between program implementation and (a) classroom processes, (b) teacher use of class time, and (c) student outcomes.

Findings from these and related analyses are summarized in this section.

Program Implementation and
Classroom Processes

Four separate questions were addressed in the analysis of the relationship between degree of implementation and classroom processes: "To what extent did implementation of the critical dimensions of the ALEM lead to the patterns of classroom processes that the program is designed to achieve?"; "Did differences in the overall degree of implementation lead to significant differences in classroom processes?"; "Did improvements in implementation result in positive changes in classroom processes?"; and, "Were the differences in classroom processes in ALEM and non-ALEM classrooms characterized by different degrees of implementation?"

To investigate whether program implementation led to the desired patterns of classroom processes, the degree of implementation data and the observation data on classroom processes collected in all the first- and second-grade classrooms (N = 72) participating in Studies I and II were analyzed (Wang & Walberg, 1983). The Student Behavior Observation Schedule (Wang, 1974) was used to obtain the classroom process data. A significant overall relationship between implementation and classroom processes was suggested by the results from the canonical correlation analysis (canonical $R = .36$, $p < .01$). In addition to this overall relationship, the extent to which classrooms at the three different degree of implementation levels exhibited distinct patterns of classroom processes was analyzed. The results from this analysis are summarized in Table 4.

Insert Table 4 about here

As with the implementation data, some consistent patterns of differences in classroom processes were noted among groups of classes at the three implementation levels. For example, the data on the differences in the frequency of management interactions between teachers and students suggest a pattern of lower degree of implementation associated with greater frequencies of observed management interactions between teachers and students. The data also suggest that the interactions among students were more constructive in classrooms at the higher degree of implementation levels and that students in the higher degree of implementation classrooms seemed to spend less time working in individual settings, compared to those in the average and low degree of implementation classrooms.

Differences also were found in the types of activities in which students engaged and the manner in which learning tasks were performed. Students in the high degree of implementation classrooms were observed to spend significantly more time on student-selected, exploratory learning tasks, compared to students in the average and low degree of implementation classrooms. In addition, students in the high degree of implementation classrooms exhibited more on-task behavior, and they were less distracted. (Note that statistical analyses of the differences were not performed, due to the large differences in the numbers of classes among the three degree of implementation groups.)

An alternate way of examining the relationship between classroom processes and degree of implementation is to analyze the extent to which concomitant changes in classroom processes were noted as program implementation improved from fall to spring. This was one of the questions addressed in Study II (Wang, Nojan, Strom, & Walberg, in press). Results from the analysis, as shown in Table 5, suggest consistent patterns of changes from fall to spring in classroom processes in the hypothesized directions as the degree of implementation improved over time (as shown in Table 1). For example, student-initiated interactions with teachers increased significantly from fall to spring, while teacher-initiated interactions decreased. Teacher-student interactions occurred more frequently for instructional purposes and less frequently for management purposes. In addition, students were observed to spend increasingly greater proportions of their time on self-initiated tasks.

Insert Table 5 about here

Classroom process data from Study II also were analyzed to investigate the extent of any differences in classroom processes as the result of the previously noted differences in the nature of the programs implemented in the ALEM and non-ALEM classrooms (Wang, in press b). Some of the major hypothesized differences in classroom processes are suggested by the data (see Table 6). The ALEM students initiated interactions with teachers more often than did the non-ALEM students (a difference of 28.4 percentage points), and the ALEM students interacted

with their teachers significantly more often for instructional purposes than for management purposes. While no major differences were noted between the two groups of students in terms of the percentages of time spent working in group and individual settings, the ALEM students were observed to be significantly more on-task than the non-ALEM students and to spend significantly less time waiting for teacher help.

Insert Table 6 about here

Results from the analysis of classroom process data across the various studies discussed in this paper suggest that as critical program features were established, so were classroom processes that are hypothesized to facilitate successful student learning as portrayed in the effective teaching literature (e.g., high rates of time-on-task, increased instructional interactions with teachers, low incidence of disruptive behavior). This finding is replicated in results from the analysis of differences in the data for fall and spring, the analysis of differences in classroom processes in classrooms with high degrees of implementation and those with comparatively lower implementation scores, and the analysis of differences in classroom processes for ALEM and non-ALEM classes.

One particularly noteworthy implication is that it is possible, through the implementation of adaptive instruction, to attain classroom processes generally recognized as positive in the effective teaching research literature. The manner in which students spent their school time and the nature and patterns of interactions between teachers and

students are examples of such classroom processes. Among the most frequent criticisms of adaptive instruction programs is that they result in ineffective use of time by teachers and students. Many have argued that a major design flaw of such programs is the requirement that students spend large amounts of time working alone, and that time spent by students working independently generally has tended to be associated with lower rates of time-on-task. Data from the ALEM classrooms seem to suggest findings to the contrary.

Program Implementation and Teacher Use of Class Time

Many practical problems have been encountered in efforts to establish adaptive instruction programs in school settings. Among those cited most frequently are the sometimes intractable demands on teachers' time and the lack of supports that would enable teachers to spend more time on instruction-related, rather than management-related, activities. Therefore, a major task in the design of adaptive instruction programs is the development of ways to increase the amount of school time teachers devote to instruction. This task has been central to the design and implementation of the ALEM.

To investigate the impact of the ALEM's implementation on teacher use of class time, observation data from Study II on the manner in which teachers spent their school day in the ALEM mainstreaming classrooms were examined (Wang, 1983b). The primary objective of the analysis was to characterize the distribution patterns for time actually spent by teachers performing various functions. The focus was on addressing four

questions: "What was the overall pattern of time distribution among the major teacher functions?"; "Did patterns of teacher time use differ in classrooms with different degrees of program implementation?"; "Did the amount of teacher time spent on different functions vary according to instructional grouping (i.e., individual, small-group, or whole-class)?"; and, "Did the amount of instructional and non-instructional time spent by teachers vary according to differences in student learning characteristics and needs (e.g., according to whether students were identified as mainstreamed handicapped, academically gifted, or general education)?"

Overall patterns of teacher time use. The percentages of class time spent by teachers on various instructional and non-instructional functions are summarized in Figure 2. As shown in the first pie chart in Figure 2, teachers in the ALEM classes were observed to spend averages of 81.1% (approximately 49 minutes per hour) of their time on instructional functions and 18.9% on non-instructional functions. Of the time devoted to instruction-related activities (shown in the second pie chart in Figure 2), 93.4% (approximately 46 minutes per hour) was spent actually instructing students. These activities included introducing, and providing instruction in, new tasks; conducting review lessons; and giving instruction-related management directions (e.g., going over workbook directions, explaining how to get reference materials for specific learning tasks). In addition, teachers were observed to spend 2.8% of their instruction-related time on evaluation activities such as checking students' work, giving feedback, and assessing students' learning progress. Planning activities that

included prescription of learning tasks and discussion of individual progress plans with students accounted for 3.8% of the time spent by teachers on instruction-related activities. Similarly, the third pie chart in Figure 2 shows the breakdown of the 18.9% of the time that teachers spent on non-instruction-related activities such as managing student behavior and engaging in informal conversations with students regarding personal or other non-instruction-related matters. The 39.1% of non-instructional time spent on "other activities" included conversations with school staff, parents, and visitors and unexplained temporary absences from the classrooms.

Insert Figures 2 and 3 about here

Degree of program implementation and patterns of teacher time use. A question of interest from the instructional design perspective was whether the degree to which critical program design dimensions were in place resulted in differences in teacher time use. Figure 3 provides a summary of the results from the analysis of time use by teachers in classrooms with overall degree of implementation scores at the high, average, and low levels. Statistically significant differences were noted in the overall patterns of instructional/non-instructional time use for the three groups of teachers. Furthermore, as shown in Figure 3, the percentage of time spent on instruction-related activities increased from the low to the high degree of implementation groups. In addition to the overall amounts of time spent by teachers on instructional and non-instructional functions, major differences were

noted in the distribution of time for the various activities within each of the two categories. For example, teachers in the high and average degree of implementation classrooms were observed to spend more time prescribing and checking work than did teachers in the low degree of implementation classes. Teachers in the latter group of classes spent significant amounts of their evaluating and planning time doing record keeping.

Some major differences also were observed in the distribution of non-instructional time for teachers in classrooms at the different degree of implementation levels. Teachers in the high degree of implementation classrooms tended to spend less of their non-instructional time on behavior management. In addition, teachers in classrooms with high degree of implementation scores were observed to spend about equal amounts of time on behavior management when students worked individually as when they worked in whole-class instructional situations; teachers in average degree of implementation classrooms were observed to spend more time on behavior management when students worked individually than when they worked in whole-class instructional situations; and teachers in the low degree of implementation classrooms seemed to spend the greatest amount of their behavior management time in whole-class instructional situations.

Instructional grouping and teacher time use. To investigate the extent to which the amounts of time spent by teachers on different types of instructional activities were related to instructional grouping, the manner in which time was spent working with individual students, in small groups, and with the whole class was examined. The results are summarized in Table 7.

Insert Tables 7 and 8 about here

Differences in the patterns of time use are suggested by the data on the percentages of time that teachers spent on the various functions across the three instructional groupings. It should be noted here that the ratios reported in Table 7 are based on 79.67% of the teachers' total class time, which is approximately 48 minutes per hour. Therefore, the percentage of time that teachers were observed to spend working with individual students, for example, reflects the proportion of time spent on this activity during 48 minutes of each hour. It is of interest to note that, while a larger proportion of the teachers' time spent working in small-group settings was expended on instructing (78.1%), when compared to the instructing time spent with individual students (57.18%) or with the whole class (61.26%), a different picture is suggested when the actual numbers of minutes are examined. The 78.1% of teachers' time spent instructing in small groups represents approximately 2.42 actual minutes per hour, and the 57.18% of the time spent providing instruction for individual students, on the other hand, is equal to approximately 26.25 minutes per hour. It is also noteworthy that teachers were observed to spend more time on behavior management functions when working with the whole class, compared to the time spent on this function in individual and small-group settings. Teacher functions such as checking work, prescribing, and conversing with students for personal reasons only occurred when working with individual students.

Student characteristics and teacher time use. Another interest in the analysis of teacher time use under the ALEM was the extent to which the nature and amount of instruction varied for students with different learning characteristics and needs. The contention here is that the extent to which teachers spent varying amounts of time on different types of instructional and non-instructional tasks with students who have different learning characteristics and needs would be an indicator of adaptive instruction. Results from the analysis are summarized in Table 8.

As suggested by the data presented in the last row of Table 8, the differences in the total percentages of teacher time (instructional and non-instructional) spent with general education, mainstreamed handicapped, and academically gifted students were negligible. There were some notable variations, however, in the time teachers spent performing specific instructional and non-instructional functions with the three different types of students. For example, the teachers seemed to spend only slightly different percentages of time instructing the three types of students. However, when the per-student percentages of time spent on instructing were compared with the time spent giving task-specific procedural directions, major differences were noted. The teachers were observed to spend proportionately greater amounts of time giving task-specific procedural directions to the academically gifted students (5.66% per student), compared to the time spent instructing these same students (3.4% per student). By contrast, there was little difference between the time spent instructing the general education and

handicapped students and the time spent giving task-specific procedural directions to these two groups of students.

Differences also were noted in the patterns of teacher time spent with individual students for planning and evaluating their learning. Teachers tended to spend more time with the handicapped students on planning activities (e.g., prescribing tasks, record keeping) than with the academically gifted or general education students. In addition, more time was spent evaluating the work of the general education and handicapped students, compared to the amount of time spent evaluating the work of gifted students. Teachers also seemed to spend more time managing the behaviors of handicapped students, compared to the behavior management time spent with the academically gifted and general education students. Similarly, variations were noted in the amounts of time spent conversing with students about personal matters. Teachers tended to spend more time chatting with general education and gifted students than with handicapped students.

As suggested by the series of analysis discussed above, teachers' use of time in the context of the ALEM is considered to be both an independent and a dependent variable. As an independent variable, time is seen as an instructional design variable that can be manipulated (and should be manipulated) in order to adaptively respond to the needs of individual students. The varying patterns of teacher time use observed across different settings and among individual students with different learning characteristics are viewed, on the other hand, as an indicator of adaptive instruction at work and, therefore, as a dependent variable. Nevertheless, the descriptive nature of the data makes it impossible to

draw any direct implications relating differences in teacher time use to student learning. The data can be interpreted only as descriptive of observed differences. For example, no assertions can be made about the meaning of the differences in the amounts and purposes of time spent by teachers with gifted students and with mainstreamed handicapped students. However, the data do provide a descriptive base for characterizing teacher time use under the ALEM.

Program Implementation and Student Outcomes

Analysis of the ALEM's impact on student achievement in math and reading focused on two questions: "How did the achievement of ALEM students compare with that of non-ALEM students?"; and, "Did students with varying prior achievement levels make comparable achievement gains under the ALEM?" The latter question, in particular, was directed specifically at assessing the effects of adaptive instruction. The hypothesis is that if adaptive instruction provisions for effectively meeting the learning needs of individual students can be successfully achieved under the ALEM, then all students should be able to make expected, if not greater, achievement gains, despite individual differences in prior achievement and learning characteristics.

Scores on standardized achievement tests in math and reading that are routinely administered by the school districts participating in the four studies as part of their annual assessment programs were used in the analysis of the ALEM's impact on student achievement. Three types of analysis were performed: comparison of students' achievement scores

in math and reading with the national norm, comparison of achievement test results for ALEM and non-ALEM students, and comparison of achievement results for students with varying learning characteristics and needs. Achievement results from both the Follow Through sites (Studies I and III) and the mainstreaming sites (Studies II and IV) were included in the analysis.

Comparisons with the national norm and with non-ALEM comparison groups. Results from Studies I and II showed that the mean scores for students from the ALEM Follow Through classrooms were well above the estimated population norms (Branden & Weis, 1977) for students from similar low-income families. Furthermore, the mean percentile scores in math and reading, in general, were found to be consistently at or above the national norm, despite the predicted below-national-norm achievement average for Follow Through students (Wang & Walberg, 1983). For example, the achievement data from Study I showed that, overall, more than the expected 25% of students had scores in math and reading that were at or above the 75th percentile. (According to the national norm, 25% of the students could have been expected to have scores at or above the 75th percentile.) The percentages of students with percentile ranks at or above 75 ranged from 17 (third-grade reading) to 46 (first-grade math). Likewise, examination of the distribution of scores in the bottom quartile showed that, in every case, less than 25% of the students were found to have scores below the 25th percentile (25% being the national norm). The range of percentile ranks was 10 (first-grade math) to 23 (third-grade math). In addition, comparison of students' achievement scores for two consecutive years (Study I: Spring, 1981;

Study III: Spring, 1982) suggests improvement over time. Increases were noted in the numbers of students with achievement scores at or above the 75th percentile, and decreases were noted in the numbers of students with scores at or below the 25th percentile.

Comparable positive achievement results under the ALEM were replicated in Studies II and IV. Data from Study IV showed, for example, that statistically significant gains in math and reading were made by both the general education students and the mainstreamed special education students (Wang, Peverly, & Randolph, in press). The mean percentile ranks in reading for the general education students in this study were 60.7 for the second grade, 65.0 for the third grade, and 66.1 for the fourth grade. The mean percentile rank scores for these students in math were 71.0 for the second grade, 75.7 for the third grade, and 66.1 for the fourth grade. It is particularly noteworthy that considerable percentages of the special education students had achievement scores that fell at or above the 75th percentile (according to the test norm). For example, 42.3% of the fourth-grade, special education students had math scores ranked in the upper quartile, and 28.6% had reading scores at or above the 75th percentile.

Comparisons of math and reading achievement for ALEM and non-ALEM students were based on the standardized achievement test results from one of the sites in Study II where a control group was set up specifically for comparison purposes. General education and special education students in the school were randomly assigned to either ALEM classrooms or classrooms where handicapped students were pulled out each morning to attend a resource room program. The data suggest a

consistent pattern of greater achievement gains for the mainstreamed handicapped and gifted students in the ALEM classrooms, compared to the achievement gains for students in the non-ALEM, comparison classrooms (Wang, in press b).

Comparison of students with varying learning characteristics and needs. An ultimate goal of adaptive instruction is to increase the chances for all students to experience schooling success, despite individual differences in prior achievement level and related learning characteristics. A basic contention is that, if instructional programs are well adapted to student differences, all students, in spite of varied learning needs, should be able to make achievement gains that are at or above the expected levels. Thus, one criterion for testing the efficacy of an instructional program aimed at adapting to individual differences is the extent to which all students make expected achievement gains.

Data from Study IV were used to investigate whether general education and special education students in the ALEM mainstreaming classrooms made expected, or greater, achievement gains. The results showed that the average gains for both groups of students were at or above the expected one year in grade equivalent. The mean gains for general education students were 1.87 in math (which is significantly different from the expected gain of 1.00, $p < .001$) and 1.19 in reading ($p < .01$). The achievement gains for the mainstreamed special education students were 1.08 in math and 1.04 in reading. While the achievement gain scores for the special education students were not found to be significantly beyond the expected norm of one year, they were

significantly greater in both reading (t = 2.62, $p < .01$) and math (t = 2.62, $p < .01$) than the expected gains for students with comparable special education classifications. The average achievement gain for students in the district with similar classifications was six months. Further evidence of the program's impact is found in the fact that approximately 30% of the mainstreamed special education students in Study IV were recommended by their teachers as potential candidates for decertification. The average decertification rate in the school district for special education students with similar classifications who are placed in self-contained, special education classes is 2.8%. Thus, the overall achievement results seem to suggest the positive impact of the ALEM on the achievement of students with varied prior achievement levels and learning characteristics.

Analysis of Causal Links among Program Implementation, Classroom Processes, and Student Outcomes

A final analysis of tne data on the ALEM's implementation and effects was an attempt to examine the extent to which program implementation was related to the observed classroom processes and achievement outcomes. Figure 4 shows a theoretical causal model of adaptive instruction. As shown in the figure, relationships among six major constructs were hypothesized. Three of the constructs are related to the ALEM's design. They are classroom organization, instructional planning and classroom management, and teaching and learning functions. Of the three remaining constructs, one is related to student learning

characteristics (prior achievement), and two are program outcome constructs (classroom processes and post achievement).

Insert Figure 4 about here

The student prior achievement construct in the model was measured by students' standardized achievement scores from the previous school year. The classroom organization construct included measures of the degree of implementation for three of the ALEM's critical program dimensions--Arranging Space and Facilities, Establishing and Communicating Rules and Procedures, and Managing Aides. The construct, instructional planning and classroom management, included measures of degree of implementation for five critical dimensions of the ALEM--Creating and Maintaining Instructional Materials, Diagnostic Testing, Monitoring and Diagnosing, Prescribing, and Record Keeping. The construct, teaching and learning functions, included measures of the degree of implementation for four of the ALEM's critical program dimensions--Developing Student Self-Responsibility, Instructing, Interactive Teaching, and Motivating. The classroom processes construct included observational data related to the manner in which students spent their class time (e.g., on-task, distracted, waiting for teacher direction or help). Finally, students' post achievement was measured by standardized achievement tests administered by the school districts at the end of the school year.

Path analysis procedures (Pedhazur, 1975) were applied to test the hypothesized causal links shown in Figure 4. Math data from Study IV were used to examine the relationship between program implementation and classroom processes and student post achievement. Overall, the data suggest that, after controlling for the effects of prior achievement in math, the four program-related constructs--classroom organization, instructional planning and classroom management, teaching and learning functions, and classroom processes--were found to have significant positive effects on students' post achievement in math. Results from further analysis of the relationships among the constructs are reported in Figure 4.

A number of significant causal relationships are suggested by the data. Prior achievement in math, as would be expected, had a large significant effect on post achievement. In addition, several of the hypothesized causal linkages between program design, classroom processes, and student achievement are supported by the data. Some interesting examples are the positive relationship between the instructional planning and classroom management construct and post achievement in math (Beta = .42, $p < .01$), and the moderate (Beta = .24, $p < .10$), but positive, relationship between classroom processes and post achievement. The findings also indicate that the classroom organization construct was significantly related to the instructional planning and classroom management construct and the teaching and learning functions construct (Beta = .42 and .36, respectively). Furthermore, the teaching and learning functions construct was found to have a significant positive effect on classroom processes (Beta = .17, p

< .05). It also should be pointed out that two significant negative relationships were found: the effect of the instructional planning and classroom management construct on classroom processes (Beta = -.19 $p <$ .05), and the effect of prior achievement on teaching and learning functions (Beta = -.16, $p <$ .05).

While results of the path analysis suggest an overall positive causal relationship between program implementation and hypothesized program outcomes, they also indicate the need for further analysis, particularly insofar as some of the confounding and seemingly counter-intuitive findings are concerned (e.g., the significant negative effects of instructional planning and classroom management on classroom processes and their significant positive effects on student achievement). Thus, a cautionary note regarding the path analysis findings is in order. Since they represent a preliminary examination of hypothesized causal relationships among the major program design and outcome constructs, they are considered to be only suggestive. Further investigations involving replication of the causal model, analyses of variables within and across constructs included in the model, inclusion of other outcome measures of attitudes and academic achievement, and testing of rival hypotheses and alternative causal models are the necessary next step. Additional work in this area is seen as crucial for empirical validation of the hypothesized impact of the ALEM on student outcomes.

In summary, it can be stated that the results discussed in this chapter provide substantial support for three major conclusions. First, it is possible to establish and maintain average to high degrees of implementation of the ALEM on a large-scale basis in a variety of school settings. This is clearly substantiated by the replication of findings across the four studies. Second, as critical features of the ALEM are established, so are classroom processes that are hypothesized to facilitate effective adaptive instruction in classroom settings. Finally, implementation of the ALEM and the presence of desired classroom processes of adaptive instruction seem to facilitate student achievement. While, admittedly, further analysis of the causal relationships among these variables is needed, the overall results from the four studies seem to suggest a consistent pattern of higher achievement scores for ALEM students, when compared with those for non-ALEM students. Particularly noteworthy are the data on the higher-than-expected percentages (based on the national norm of 25%) of ALEM students who had achievement scores at or above the 75th percentile (including some of the mainstreamed handicapped students and students from the Follow Through program); and the finding that mainstreamed handicapped students in ALEM classrooms made an average gain of a little over one year in grade equivalent scores in math and reading achievement, compared to the average gain of six months for students with similar handicapping labels. These achievement test results may be regarded as one indicator of adaptive instruction at work. That is, they demonstrate the possibility that students with poor prognoses for academic achievement can succeed in their school learning through the provision of the type of adaptive instruction imbedded in the design of

the ALEM. Thus, despite the limitations of attempting to generalize the implications of findings from studies of a single program, there seems to be substantial evidence that suggests the feasibility and effectiveness of making educational provisions for individual differences in regular classroom settings.

In addition to the data on program efficacy, perhaps the most noteworthy work on the development and evaluation of the ALEM includes the identification of critical programming features and the specification of required operating conditions for providing effective adaptive instruction. The development of systematic procedures for evaluating the degree of program implementation has greatly facilitated program refinement efforts, while also helping to increase understanding of the workings of adaptive instruction. The results from periodic "readings" and systematic analysis of the degree of program implementation provide information not only for program validation and refinement purposes, but also for use by school personnel in planning individually-tailored, staff development activities for improving program implementation.

Work on development and evaluation of the ALEM has raised several methodological issues related to evaluation design and analytical procedures, as well as some instructional design questions. Three lines of research are clearly suggested: The first two relate to furthering understanding and development of a theory of adaptive instruction and refinement of adaptive instruction practices in schools; the third relates to an overarching methodological issue surrounding study of the implementation of innovative educational programs in school settings in general and the subsequent consequences of such implementation.

The first line of suggested research centers on a fundamental question that has guided past work and probably will be the basis of instructional design research on adaptive instruction for years to come. The question is, "Given that we have been able to create and maintain an educational program which exemplifies quite closely our design specifications, does the program work as it ought to; and, how do we know?" Summaries of research findings presented in this chapter and elsewhere suggest that at a rather gross level, when the ALEM's critical program dimensions are in place, certain of what Glaser (1982a) has termed the "large practical variables" of effective schooling are observed to be present. Such variables, including efficient use of time by teachers and students and increased interactions between teachers and students on instructional matters, in turn seem to lead to certain desired student outcomes. Several findings from the analysis of the ALEM's impact, however, clearly indicate the need for further analysis and empirical validation. For example, while some of the relationships (e.g., the relationship between the program's structural dimensions, such as classroom organization, and student achievement in math) were found to be quite strong, others were moderate and, in a few cases, indicated quite puzzling negative effects.

These results suggest that analysis of the interrelationships among critical program dimensions and the resulting classroom processes and student outcomes will require much more fine-grained, micro-level analyses than the type that have been utilized thus far in the study of the ALEM. Such analyses are likely to result in further delineation of

the causal relationships among the variables within and across critical program dimensions and, perhaps even more important, in the development of alternative models that deal with rival hypotheses about these relationships. One example of further work in this area is the inclusion of variables which are known to be associated with student achievement but have not been included in the analytical model used for the conceptualization and evaluation of adaptive instruction (e.g., resource utilization, quality of instruction, nature of the learning task). Another example is investigations of whether, and to what extent, specific program design dimensions, and/or particular performance indicators within given dimensions, are differentially predisposed to producing a range of desired classroom processes and student achievement and attitudinal outcomes.

Research to examine closely the quality of instruction as it is related to student achievement seems particularly timely, given the present state of the art of research on subject-matter learning (e.g., Anderson, 1976; Resnick & Ford, 1981; Greeno, 1980); recent developments in cognitive-instructional psychology (e.g., Calfee, 1981; Glaser, 1982a, b; Simon, 1981); and continuing developments in the research on effective teaching in general and the provision of adaptive instruction in particular (Wang & Lindvall, 1984). A program of research that focuses on identifying plausible ways to incorporate recent advances in these areas into further refinement of the quality of instructional-learning adaptations would seem to be a fruitful and direct way of addressing the need to improve student capabilities, as well as the need to improve the quality of education for all students through the adaptive instruction approach.

The second line of research is related to delineation of instructionally-relevant, individual-difference variables. Modern models of schooling have come to recognize that dual adaptation is required for the instructional-learning process--that is, adaptation in the instructional process to accommodate student differences (i.e., modification of the learning environment), and adaptation in the ability of individual students to respond successfully to task demands (i.e., modification within the learner). Nevertheless, even in the case of widely recognized, research-based programs of adaptive instruction, little work has been done to date on the actual nature of those adaptations that are required if the individual learner is to succeed. The designs of such extant programs, including the ALEM, tend to be concerned with a limited number of individual-difference variables. Furthermore, very few of these variables are incorporated in planning and the actual instructional process, despite the research suggesting a wide range of individual-difference variables as correlates of learning (Wang & Lindvall, 1984).

The third line of research suggested by the work described here is related to refinement and improvement of research methodologies for analysis and evaluation of innovative schooling practices. Several quite complex problems have been raised. Although these problems are not new, their resolution seems even more critical given the state of the art of the design and study of adaptive instruction in classroom settings.

One problem has to do with the difficulty of obtaining experimental controls for conducting instructional experimentations or intervention studies in naturalistic settings and the scientific credibility of findings from descriptive field research of the type discussed in this chapter. Experience in the implementation and study of the ALEM and the work of others have shown that the participation of schools and teachers in an innovative program tends to be a matter of choice rather than assignment by central administrators. While such identification of sample populations can portend well for program implementation, it precludes the evaluation of randomized program treatments. One common solution to this design problem is use of the replication strategy. The basic contention is that results on program impact can be inferred from quasi-experimental studies or correlational studies with some confidence, if they are repeated under a variety of conditions. Nevertheless, while the replication strategy adopted in the study and analysis of the ALEM's impact has provided intuitively sound evidence of support for the particular adaptive instruction approach reflected in the program's design, the research associated with the ALEM's design and evaluation can be characterized only as suggestive at best.

Another related technical problem has to do with the fact that, in cases where a high degree of program implementation is maintained (a desired outcome of any innovative school improvement program), there is very little variance in the implementation measures. This low variance, which typically is associated with high degrees of program implementation, when combined with the multicollinear nature of the variables, has been identified as a persistent psychometric problem with

analyses of relationships between program implementation and hypothsized program outcomes. There is an obvious need to identify and develop alternative designs and methodologies for obtaining empirical evidence to answer the fundamental questions, "Does the program work?"; and, "How do we know?"

From the methodological perspective, the importance of greater technical sophistication in the study of adaptive instruction programs is clear. Much work is needed in the development of procedures for examining non-linear effects and non-recursive relationships, as well as interactive and contextual effects that typically are associated with instructional design and program validation and evaluation research of the type discussed in this chapter. Research designs incorporating multiple indicators or triangulation data collection procedures are indicated for future investigations of the implementation and effects of innovative programs.

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References

Anderson, J. R. (1976). Language, memory, and thought. Hillsdale, NJ: Erlbaum.

Bennett, N. (1976). Teaching styles and pupil progress. Cambridge, MA: Harvard University Press.

Bloom, B. (1976). Human characteristics and school learning. New York: McGraw Hill.

Branden, A., & Weis, L. (1977). Alternative presentation of the MAT data: Follow Through national evaluation. Paper presented to the United States Office of Education, Office of Planning and Evaluation, Elementary and Secondary Education Programs, Washington, DC.

Brophy, J. (1979). Teacher behavior and its effects. Journal of Educational Psychology, 71(6), 733-750.

Calfee, R. (1981). Cognitive psychology and educational practice. In D. C. Berliner (Ed.), Review of research in education, (Vol. 9). Washington, DC: American Educational Research Association.

Glaser, R. (1967). Criterion-referenced testing for measurement (LRDC Publications Series R41). Pittsburgh, PA: University of Pittsburgh, Learning Research and Development Center.

Glaser, R. (1977). Adaptive education: Individual diversity and learning. New York: Holt, Rinehart and Winston.

Glaser, R. (Ed.). (1982a). Advances in instructional psychology (Vol. 2). Hillsdale, NJ: Erlbaum.

Glaser, R. (1982b, August). Education and thinking: The role of knowledge. Paper presented as the Edward L. Thorndike Award Address at the annual meeting of the American Psychological Association, Washington, DC.

Greeno, J. G. (1980). Psychology of learning, 1960-80: One participant's observations. American Psychologist, 35, 713-728.

Johnson, D. W., Maruyama, G., Johnson, R., Nelson, D., & Skon, L. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. Psychological Bulletin, 89, 47-62.

Lindvall, C. M., & Cox, R. C. (1967, February). A rationale and plan for the evaluation of the Individually Prescribed Instruction project. Paper presented at the annual meeting of the American Educational Research Association, New York.

Marshall, H. H. (1981). Open classrooms: Has the term outlived its usefulness? Review of Educational Research, 51, 181-192.

National School Public Relations Association. (1981). Good teachers: What to look for. Arlington, VA: National School Public Relations Association.

Pedhazur, E. J. (1975). Analytic methods in studies of educational effects. In F. N. Kerlinger (Ed.), Review of research in education. Itasca, IL: Peacock.

Peterson, P. L. (1979). Direct instruction reconsidered. In P. L. Peterson and H. J. Walberg (Eds.), Research on teaching: Concepts, findings, and implications. Berkeley, CA: McCutchan.

Resnick, L. B., & Ford, W. W. (1981). The psychology of mathematics for instruction. Hillsdale, NJ: Erlbaum.

Resnick, L. B., Wang, M. C., & Kaplan, J. (1973). Behavior analysis in curriculum design: A hierarchically sequenced introductory mathematics curriculum. Journal of Applied Behavioral Analysis, 6, 679-710.

Rosenshine, B. V. (1979). Content, time, and direct instruction. In P. L. Peterson & H. J. Walberg (Eds.), Research on teaching: Concepts, findings, and implications. Berkeley, CA: McCutchan.

Simon, H. A. The sciences of the artificial. (1981). Cambridge, MA: MIT Press.

Smith, E. (1976). Implementation of the Self-Schedule System: The teacher's perspective. In M. C. Wang (Ed.), The Self-Schedule System for instructional-learning management in adaptive school learning environments (LRDC Publications Series 1976/9). Pittsburgh, PA:

University of Pittsburgh, Learning Research and Development Center.

Stone, R., & Vaughn, L. (1976). Implementation and evaluation of the Self-Schedule System in an adaptive school learning environment. In M. C. Wang (Ed.), The Self-Scnedule System for instructional-learning management in adaptive school learning environments (LRDC Publications Series 1976/9). Pittsburgh, PA: University of Pittsburgh, Learning Research and Development Center.

Walberg, H. J. (1983). Synthesis of research on teaching. In M. C. Wittrock (Ed.), Third handbook of research on teaching. Wasnington, DC: American Educational Research Association.

Wang, M. C. (Ed.). (1974). The use of direct observation to study instructional-learning behaviors in school settings (LRDC Publications Series 1974/9). Pittsburgh, PA: University of Pittsburgh, Learning Research and Development Center.

Wang, M. C. (1980a). Adaptive instruction: Building on diversity. Theory into Practice, 19(2), 122-127.

Wang, M. C. (1980b). The degree of implementation assessment measures for the Adaptive Learning Environments Model. University of Pittsburgh, Learning Research and Development Center.

Wang, M. C. (1981). The use of the Data-Based Staff Development Program to improve program implementation. University of Pittsburgh, Learning Research and Development Center.

Wang, M. C. (1983a). Development and consequences of students' sense of personal control. In J. M. Levine & M. C. Wang, (Eds.), Teacher and student perceptions: Implications for learning. Hillsdale, NJ: Erlbaum.

Wang, M. C. (1983b). Time use and the provision of adaptive instruction. In L. W. Anderson (Ed.), Time and school learning. London: Croom Helm Ltd.

Wang, M. C. (in press a). An analysis of program design implications for teacher and student use of school time. In C. Fisher & D. Berliner (Eds.), Proceedings from the conference on instructional time and student achievement. New York: Longman.

Wang, M. C. (in press b). Effective mainstreaming is possible -- Provided that ... Analysis and Intervention in Developmental Disabilities.

Wang, M. C., & Birch, J. W. (1984). Effective special education in regular classes. Exceptional Children, 50(5), 391-399.

Wang, M. C., Catalano, R., & Gromoll, E. (1983). Training manual for the Implementation Assessment Battery for Adaptive Instruction (Vol. 1). Pittsburgh, PA: University of Pittsburgh, Learning Research and Development Center.

Wang, M. C., & Fitzhugh, R. J. (1978). Planning instruction and monitoring classroom processes with computer assistance. Educational Technology, February, 7-12.

Wang, M. C., & Gennari, P. (1983). Analysis of the design, implementation, and effects of the Data-Based Staff Development Program. Teacher Education and Special Education, 6(4), 211-226.

Wang, M. C., Leinhardt, G., & Boston, M. E. (1980). Individualized Early Learning Program (LRDC Publications Series 1980/2). Pittsburgh, PA: University of Pittsburgh, Learning Research and Development Center.

Wang, M. C., & Lindvall, C. M. (1984). Individual differences and school learning environments: Theory, research, and design. In E. W. Gordon (Ed.), Review of research in education (Vol. 11). Washington, DC: American Educational Research Association.

Wang, M. C., Nojan, M., Strom, C. D., & Walberg, H. J. (in press). The utility of degree of implementation measures in program evaluation and implementation research. Curriculum Inquiry.

Wang, M. C., Peverly, S., & Randolph, R. (in press). An investigation of the implementation and efficacy of a full-time mainstreaming program. Exceptional Education Quarterly.

Wang, M. C., Resnick, L. B., & Boozer, R. (1971). The sequence of development of some early mathematics behaviors. Child Development, 41(6), 1768-1778.

Wang, M. C., Resnick, L. B., & Scheutz, P. R. (1974). PEP in the Frick elementary school: Interim evaluation report 1969-70 (LRDC Publications Series 1974/13). Pittsburgh, PA: University of Pittsburgh, Learning Research and Development Center.

Wang, M. C., & Stiles, B. (1976). An investigation of children's concept of self-responsibility for their school learning. American Educational Research Journal, 13(3), 159-179.

Wang, M. C., & Walberg, H. J. (1983). Adaptive instruction and classroom time. American Educational Research Journal, 20, 601-626.

Table 1

Summary of Fall, Winter, and Spring Mean Degree of Implementation Scores in the ALEM's 12 Critical Dimensions Across All Participating Classrooms

Critical Dimensions	Study I Follow Through Classrooms (1980-81) N = 117						Study II Mainstreaming Classrooms (1980-81) N = 21						Study III Follow Through Classrooms (1981-82) N = 88						Study IV Mainstreaming Classrooms (1982-83) N = 26					
	Fall		Winter		Spring		Fall		Winter		Spring		Fall		Winter		Spring		Fall		Winter		Spring	
	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)	Means	(S.D.)
Arranging Space & Facilities	91	(12)	95	(6)	94	(13)	77	(21)	93	(9)	96	(7)	92	(14)	95	(9)	96	(5)	81	(16)	93	(10)	95	(7)
Creating & Maintaining Instructional Materials	74	(23)	86	(15)	85	(18)	78	(11)	76	(15)	74	(13)	83	(17)	91	(13)	93	(8)	75	(17)	90	(16)	95	(14)
Establishing & Communicating Rules & Procedures	79	(12)	89	(10)	90	(8)	76	(15)	92	(7)	89	(8)	82	(11)	91	(10)	89	(11)	77	(18)	90	(17)	95	(13)
Managing Aides	98	(8)	99	(6)	99	(5)	94	(22)	96	(20)	98	(7)	95	(17)	95	(16)	95	(19)	90	(26)	98	(13)	100	(0)
Diagnostic Testing	98	(8)	98	(8)	98	(9)	98	(7)	100	(0)	100	(0)	96	(12)	98	(7)	100	(3)	89	(19)	94	(13)	95	(10)
Record Keeping	96	(14)	99	(7)	98	(11)	77	(36)	87	(27)	98	(7)	94	(20)	99	(6)	98	(11)	37	(35)	92	(22)	99	(7)
Monitoring & Diagnosing	89	(12)	94	(9)	94	(9)	82	(17)	92	(9)	93	(6)	86	(16)	91	(14)	92	(11)	83	(12)	97	(6)	100	(0)
Prescribing	97	(9)	98	(10)	97	(12)	93	(14)	99	(4)	100	(0)	99	(6)	99	(7)	100	(0)	76	(21)	90	(21)	97	(15)
Interactive Teaching	87	(27)	90	(23)	90	(24)	61	(41)	82	(38)	93	(18)	88	(31)	92	(22)	91	(23)	75	(22)	95	(14)	97	(9)
Instructing	87	(13)	92	(11)	92	(10)	71	(14)	80	(11)	79	(10)	89	(15)	90	(12)	90	(13)	77	(14)	95	(8)	97	(7)
Motivating	78	(17)	89	(17)	92	(11)	69	(19)	87	(18)	92	(13)	83	(20)	95	(10)	95	(15)	91	(17)	96	(14)	98	(9)
Developing Student Self-Responsibility	75	(22)	82	(21)	87	(19)	61	(32)	69	(30)	81	(25)	73	(22)	89	(19)	79	(25)	75	(22)	91	(18)	97	(11)
Overall Averages	88	(7)	93	(6)	93	(6)*	78	(11)	88	(10)	91	(5)*	88	(9)	94	(7)	93	(7)*	77	(10)	93	(8)	97	(6)*

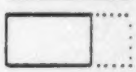
Note. The differences in the scores between Fall and Winter, and between Fall and Spring, were statistically significant ($p \leq .01$).

Table 2

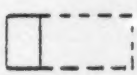
Differences in Patterns of
Mean Degree of Implementation Scores for Each Critical Dimension
Among Classrooms at the High, Average, and Low Degree of Implementation Levels
(Data from Spring, 1981 for Studies I and II)

Critical Dimensions	Mean Percentage Scores		
	High Degree of Implementation Classrooms (N=55)	Average Degree of Implementation Classrooms (N=78)	Low Degree of Implementation Classrooms (N=5)
Record Keeping	99	98	87
Prescribing	100	96	96
Diagnostic Testing	100	98	95
Managing Aides	100	98	100
Arranging Space and Facilities	98	93	77
Establishing and Communicating Rules and Procedures	93	87	79
Monitoring and Diagnosing	95	93	83
Instructing	96	87	77
Motivating	99	89	80
Creating and Maintaining Instructional Materials	92	78	62
Interactive Teaching	100	84	70
Developing Student Self-Responsibility	93	81	74
Mean Across All Dimensions	97	90	81

Dimensions for which mean scores at or above the 85% criterion level were achieved by all three levels of degree of implementation classrooms.



Dimensions for which mean scores at or above the 85% criterion level were achieved by the high and average degree of implementation classrooms, but not by the low degree of implementation classrooms.



Dimensions for which mean scores at or above the 85% criterion level were achieved by the high degree of implementation classrooms, but not by the average and low degree of implementation classrooms.

This table is taken from Wang, M.C., & Walberg, H.J. (1983). Adaptive instruction and classroom time. American Educational Research Journal, 20 (4), 601 - 625.

Table 3
Summary of Changes (Ch) in Mean Degree of Implementation Scores in the
12 Critical Dimensions For ALEM and Non-ALEM Classrooms:
Fall (F) and Spring (S) of the 1980 81 School Year
(Data from Study II)

Critical Dimensions	ALEM Classrooms (N=4)												Non-ALEM Classrooms (N=5)								
	K		Grade 1		Grade 2		Grade 3		Total				Grade 1		Grade 2		Grade 3		Total		
	F	S	F	S	F	S	F	S	F	S	(Ch.)		F	S	F	S	F	S	F	S	(Ch.)
Arranging Space & Facilities	27	100	64	100	64	100	91	100	62	100	(+38)		46	46	55	51	41	59	47	43	(-4)
Creating & Maintaining Instructional Materials	64	64	73	73	64	73	91	73	73	71	(-2)		46	27	46	41	37	55	43	44	(+1)
Establishing & Communicating Rules & Procedures	41	93	74	100	70	93	89	100	69	97	(+28)		56	78	48	69	56	63	53	68	(+15)
Managing Aides	100	100	100	100	100	100	100	100	100	100	(0)		•	•	•	•	•	•	•	•	•
Diagnostic Testing	100	100	100	100	100	100	100	100	100	100	(0)		25	0	13	25	0	13	13	19	(+6)
Record Keeping	33	100	100	100	100	100	33	100	67	100	(+33)		33	33	50	84	33	33	39	67	(+28)
Monitoring & Diagnosing	63	88	100	88	63	100	100	100	81	94	(+13)		38	50	26	44	44	57	32	50	(+18)
Prescribing	60	100	60	100	100	100	100	100	80	100	(+20)		40	40	40	30	50	40	43	36	(-7)
Interactive Teaching	0	100	100	100	100	100	100	100	75	100	(+25)		50	0	0	75	0	25	17	40	(+23)
Instructing	57	79	86	71	71	86	86	93	75	82	(+7)		71	79	54	68	50	50	58	63	(+5)
Motivating	80	100	40	40	100	100	80	100	75	85	(+10)		40	60	40	70	30	50	37	60	(+23)
Developing Student Self Responsibility	0	100	33	33	33	33	100	67	42	58	(+16)		67	0	17	50	17	0	34	20	(-14)
Total	52	94	78	90	80	90	89	94	75	92	(+17)		47	38	35	55	33	40	38	46	(+9)

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Table 4

Mean Percentages of Observed Frequencies in Major Categories of Classroom Process Variables for Classrooms at Different Degree of Implementation Levels

(Data from Spring, 1981 for First- and Second-Grade Classes in Studies I and II)

Variables	Degree of Implementation Levels					
	High (N = 29)		Average (N = 39)		Low (N = 4)	
	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
Interactions Between Teachers and Students						
Initiation						
Student	41.1	(1.7)	33.3	(1.4)	32.1	(1.9)
Teacher	58.9	(1.2)	66.7	(1.5)	67.9	(1.4)
Purpose						
Instruction	93.3	(2.3)	91.7	(2.0)	90.0	(1.7)
Management	6.7	(.6)	8.3	(.4)	10.0	(.4)
Interactions with Peers						
Sharing ideas, materials, activities, etc.	99.8	(2.3)	94.4	(2.8)	90.0	(1.8)
Disruptive	.2	(.2)	5.6	(.3)	10.0	(.3)
Setting						
Group: Interactive	5.1	(2.1)	3.0	(1.6)	3.0	(1.8)
Group: Parallel	5.1	(2.0)	2.0	(1.5)	0.0	(0)
Individual	89.8	(2.9)	95.0	(2.4)	97.0	(1.8)
Activity Type						
Prescriptive	84.7	(3.5)	96.0	(2.1)	98.0	(1.6)
Exploratory	15.3	(3.4)	4.0	(1.9)	2.0	(1.3)
Initiation						
Assigned	2.6	(3.6)	6.3	(3.7)	10.4	(3.0)
Self-initiated	97.4	(3.9)	93.6	(3.8)	89.6	(3.2)
Manner						
On-Task	86.0	(2.5)	81.0	(3.7)	76.0	(3.2)
Waiting	8.0	(1.9)	8.0	(2.7)	10.0	(2.3)
Distracted	6.0	(1.6)	11.0	(2.2)	14.0	(2.5)

This table is taken from Wang, M.C., & Walberg, H.J. (1983). Adaptive instruction and classroom time. American Educational Research Journal, 20 (4), 601 - 625.

Table 5

Mean Percentages of Observed Frequencies in Major Categories of Classroom Process Variables (Data from Fall and Spring, 1980-81 for Study II)

(N=21 classrooms)

Variables	Observation Periods: Fall Mean	Fall (S.D.)	Spring Mean	Spring (S.D.)	Probability from t-test
Interactions Between Teachers and Students					
Initiation					
Student	12.86	(.7)	41.7	(1.1)	< .05
Teacher	87.01	(2.0)	58.3	(1.4)	< .05
Purpose					
Instruction	83.57	(2.1)	92.3	(1.7)	< .05
Management	15.55	(.6)	7.3	(.3)	< .05
Interactions with Peers					
Sharing ideas, materials, activities, etc.	97.33	(2.5)	100.00	(2.1)	< .05
Disruptive	2.67	(.1)	0	(0)	< .05
Setting					
Group: Interactive	27.16	(4.5)	69.0	(4.1)	N.S.
Group: Parallel	31.18	(4.0)	23.0	(3.8)	< .05
Individual	41.66	(3.0)	8.0	(2.1)	< .05
Activity Type					
Prescriptive	61.00	(3.9)	16.0	(3.5)	< .05
Exploratory	25.48	(3.8)	13.0	(3.0)	N.S.
Other	13.52	(4.5)	71.0	(4.2)	N.S.
Initiation					
Assigned	83.08	(4.3)	23.0	(3.8)	< .05
Self-initiated	15.39	(4.2)	77.0	(3.8)	< .05
Cannot determine	1.53	(.8)	0	(0)	< .05
Manner					
On-Task	83.91	(1.9)	86.0	(2.0)	N.S.
Waiting	5.60	(1.1)	8.0	(1.8)	N.S.
Distracted	10.48	(1.5)	5.0	(.9)	N.S.

This table is taken from Wang, M.C., Nojan, M., Strom, C.D., & Walberg, H.J. (in press). The utility of implementation measures in program evaluation and implementation research: A case study. Curriculum Inquiry.

Table 6

Mean Percentages of Observed Frequencies of Classroom Processes for ALEM and Non-ALEM Classrooms

(Data from Spring, 1981 for Study II)

Comparison Variables	ALEM Classrooms (N = 4) $\bar{X}$%	(S.D.)	Non-ALEM Classrooms (N = 5) $\bar{X}$%	(S.D.)	Differences	Results from t-test
Interactions						
Interactions Between Teacher and Student						
Initiation						
Student	32.4	(1.0)	4.0	(.3)	28.4	18.9**
Teacher	67.6	(1.7)	96.0	(2.9)	28.4	6.17**
Purpose						
Instructional	95.2	(1.9)	88.1	(2.6)	7.1	1.45
Management	4.8	(.3)	11.9	(.6)	7.1	7.89**
Purpose of Interactions with Peers						
Instructional	100.0	(2.2)	99.0	(1.4)	1.0	.263
Disruptive	00.0	(0)	1.0	(.1)	1.0	.744
Activity Types						
Prescriptive	63.6	(4.3)	91.0	(3.0)	27.4	3.60**
Exploratory	26.0	(4.0)	5.5	(2.2)	20.5	3.11**
Other	10.4	(2.6)	3.5	(1.5)	6.9	.688
Setting						
Group Interactive	22.3	(3.7)	34.4	(4.4)	12.1	1.49
Group Parallel	25.1	(4.0)	20.5	(3.7)	4.5	.605
Individual	52.6	(4.7)	45.1	(4.7)	7.5	.798
Initiation						
Assigned	31.4	(4.5)	90.9	(3.9)	58.6	6.76**
Self-Initiated	68.2	(4.5)	9.0	(2.5)	59.2	7.89**
Cannot be Determined	00.4	(.3)	0.1	(.1)	.3	.638
Manner						
On-Task	90.1	(1.7)	80.0	(3.3)	10.1	1.98*
Waiting for Teacher Help	5.9	(1.5)	13.5	(1.0)	7.6	2.93*
Distracted	3.0	(.8)	6.0	(1.2)	3.0	1.50

Note. $^{*}p \leq .05$
$^{**}p \leq .01$

This table is taken from Wang, M.C. (in press). Effective mainstreaming is possible - Provided that . . . Analysis and Intervention in Developmental Disabilities.

Table 7

Time Teachers Spent on Specific Functions during Interactions with Students in Different Instructional Groupings*

Teacher Function	Instructional Grouping					
	Individual (76.56)*		Small Group (5.17)		Whole Class (18.27)	
	Percentage	Minutes Per Hour	Percentage	Minutes Per Hour	Percentage	Minutes Per Hour
Instructing	57.18	26.25	78.10	2.42	61.26	6.71
Giving Task-Specific Procedural Directions	29.44	13.52	18.73	.58	19.90	2.18
Behavior Management	3.15	1.45	3.17	.10	18.84	2.07
Checking Work	4.75	2.18	0	0	0	0
Prescribing	2.84	1.30	0	0	0	0
Conversations with Students for Personal Reasons	3.00	1.37	0	0	0	0

Note. *Numbers in parentheses indicate the percentages of time spent in the particular instructional groupings.

Table 8

Mean Percentages of Teacher Time Spent with Individual General Education, Handicapped, and Academically Gifted Students on Instructional and Non-Instructional Functions*

Teacher Functions	Mean Percentages of Teacher Time Per Student		
	General Education Students (N=672)	Handicapped Students (N=77)	Academically Gifted Students (N=35)
Instructional			
Instruction			
Instructing	3.64	3.20	3.40
Giving task-specific procedural directions	3.57	3.27	5.66
Planning	2.19	4.82	1.78
Evaluation	2.65	2.40	1.43
Non-Instructional			
Behavior Management	2.55	3.11	2.38
Conversations with Students (for personal and other non-instructional purposes)	3.56	.81	4.38
Total per-student time across functions	3.65	3.50	3.45

Note. *Results reported in Tables 7 and 8 are from Study II.

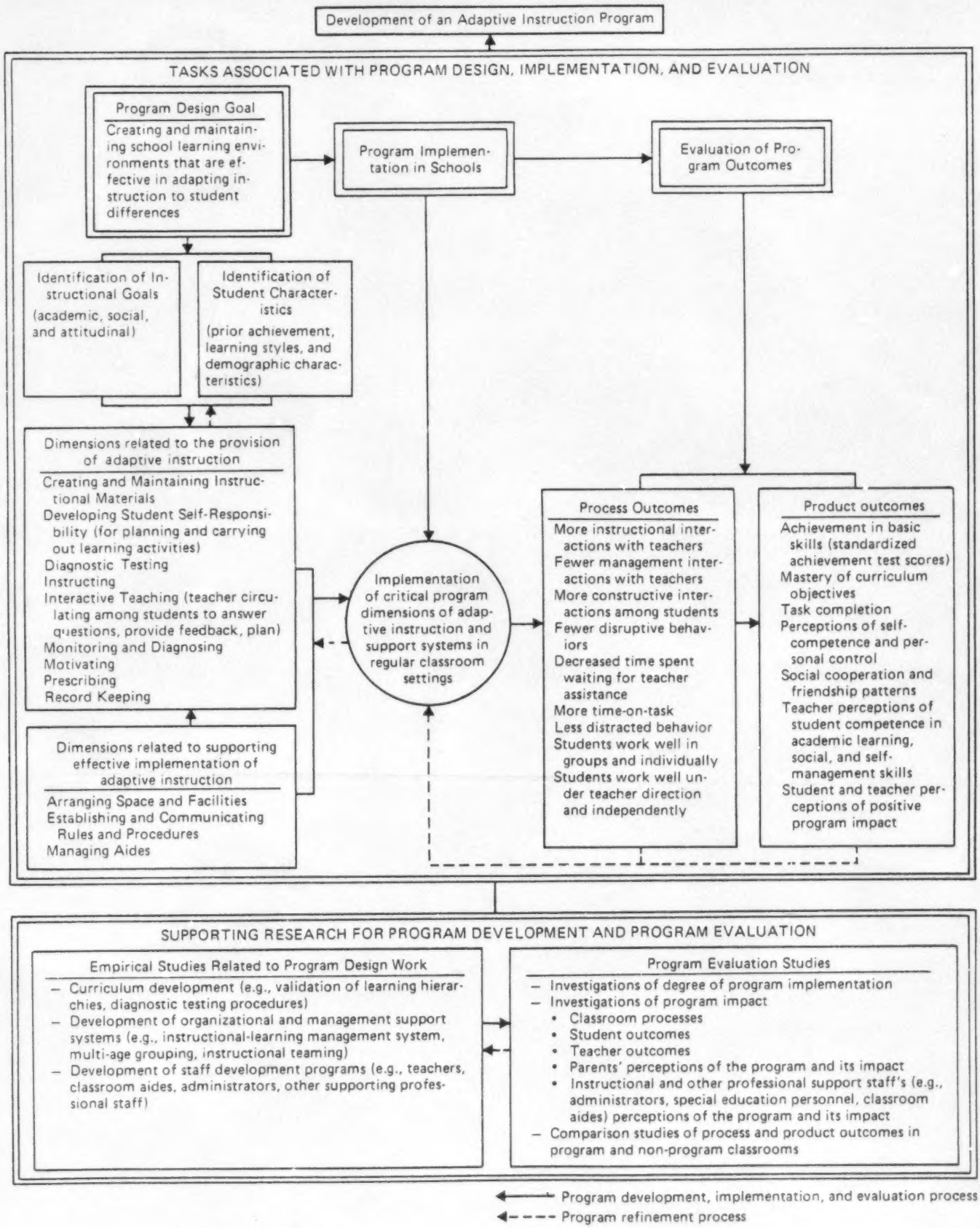

Development of an Adaptive Instruction Program
TASKS ASSOCIATED WITH PROGRAM DESIGN, IMPLEMENTATION, AND EVALUATION
Program Design Goal
Creating and maintaining school learning environments that are effective in adapting instruction to student differences
Program Implementation in Schools
Evaluation of Program Outcomes
Identification of Instructional Goals
(academic, social, and attitudinal)
Identification of Student Characteristics
(prior achievement, learning styles, and demographic characteristics)
Dimensions related to the provision of adaptive instruction
Creating and Maintaining Instructional Materials
Developing Student Self-Responsibility (for planning and carrying out learning activities)
Diagnostic Testing
Instructing
Interactive Teaching (teacher circulating among students to answer questions, provide feedback, plan)
Monitoring and Diagnosing
Motivating
Prescribing
Record Keeping
Dimensions related to supporting effective implementation of adaptive instruction
Arranging Space and Facilities
Establishing and Communicating Rules and Procedures
Managing Aides
Implementation of critical program dimensions of adaptive instruction and support systems in regular classroom settings
Process Outcomes
More instructional interactions with teachers
Fewer management interactions with teachers
More constructive interactions among students
Fewer disruptive behaviors
Decreased time spent waiting for teacher assistance
More time-on-task
Less distracted behavior
Students work well in groups and individually
Students work well under teacher direction and independently
Product outcomes
Achievement in basic skills (standardized achievement test scores)
Mastery of curriculum objectives
Task completion
Perceptions of self-competence and personal control
Social cooperation and friendship patterns
Teacher perceptions of student competence in academic learning, social, and self-management skills
Student and teacher perceptions of positive program impact
SUPPORTING RESEARCH FOR PROGRAM DEVELOPMENT AND PROGRAM EVALUATION
Empirical Studies Related to Program Design Work
– Curriculum development (e.g., validation of learning hierarchies, diagnostic testing procedures)
– Development of organizational and management support systems (e.g., instructional-learning management system, multi-age grouping, instructional teaming)
– Development of staff development programs (e.g., teachers, classroom aides, administrators, other supporting professional staff)
Program Evaluation Studies
– Investigations of degree of program implementation
– Investigations of program impact
• Classroom processes
• Student outcomes
• Teacher outcomes
• Parents' perceptions of the program and its impact
• Instructional and other professional support staff's (e.g., administrators, special education personnel, classroom aides) perceptions of the program and its impact
– Comparison studies of process and product outcomes in program and non-program classrooms
Program development, implementation, and evaluation process
Program refinement process

Figure 1. A model of design, implementation, and evaluation research for adaptive instruction.

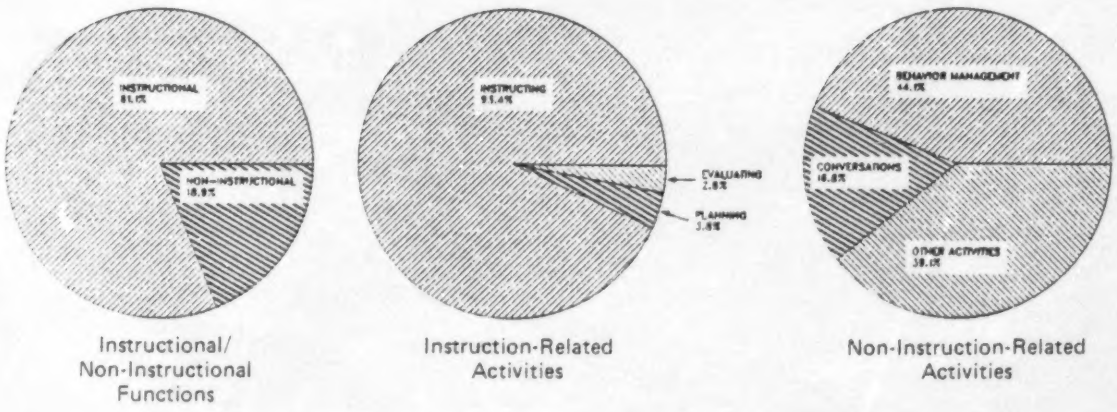


Figure 2. Summary of the distribution of teacher time use among instructional and non-instructional functions.*

(N = 28 classrooms; the mean number of observation minutes per teacher was 199.29.)

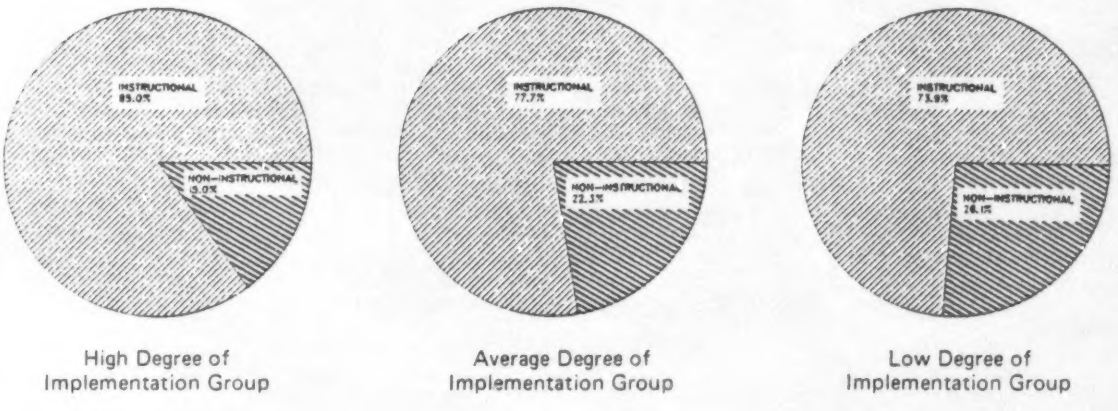
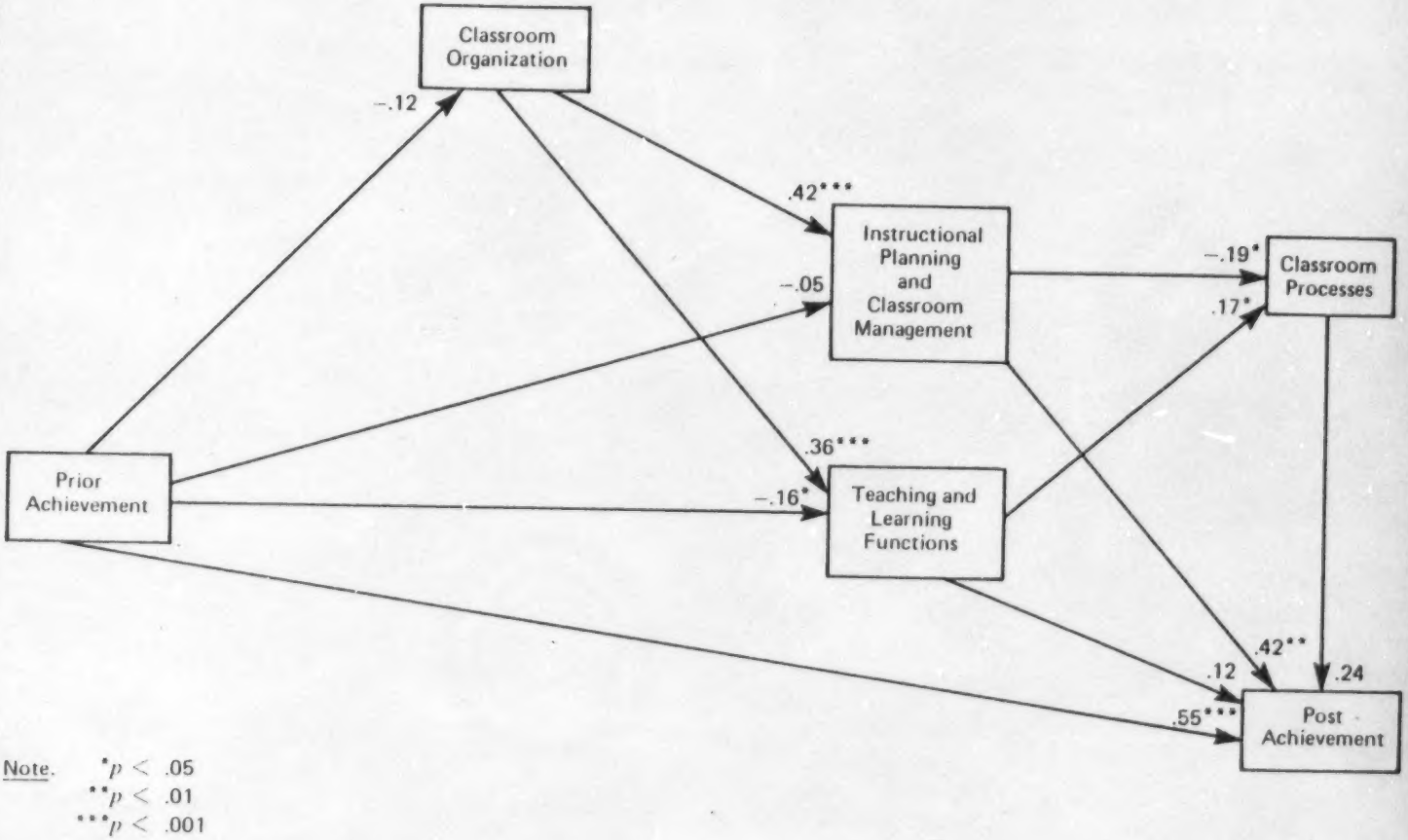


Figure 3. Summary of the distribution of teacher time use in classrooms at the high, average, and low degree of implementation levels.*

(N = 28 classrooms; the mean number of observation minutes per teacher was 199.29.)

Note. *Results reported in Figures 2 and 3 are from Study II.



Note. $^{*}p < .05$
$^{**}p < .01$
$^{***}p < .001$

Figure 4. A causal model of adaptive instruction, classroom processes, and student achievement. (Results reported are from Study IV.)